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UNIVERSITY
33
UNIVERSITEIT
BRABANT

POSTBOX 90153
5000 LE TILBURG
THE NETHERLANDS

[redacted]

DEPARTMENT OF ECONOMICS

RESEARCH MEMORANDUM

[redacted]

WAGE BARGAINING AND BUSINESS CYCLES
A GOODWIN-NASH MODEL

Eduard Ponds

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CONTENTS

INTRODUCTION*)

Distribution conflicts and wage-price dynamics in the seventies have stimulated macroeconomic thinking about the influence and the effects of collective wage bargaining on economic stability. Although the macroeconomic literature has identified several core determinants of wage increases through time, it has never paid much attention to the interdependence of collective wage bargaining and economic dynamics and to the bargaining process itself.

Some recent research tries to overcome this black box character of wage formation by introducing elements of the bargaining theory into existing macromodels. This paper is in line with these attempts. We integrate the well-known Nash-solution for the puzzle of the bargaining indeterminacy within the cyclical growth model of Goodwin (1967).

First of all, we start with a short characterization of the existing bargaining literature. Next, we set out the original Goodwin model and give some arguments why this model can benefit from an extension with bargaining elements. Then we will introduce an alternative formalisation of the Nash-solution. This formalisation enables us to describe the bargaining results of a class-compromise on distribution issues within an accumulation model. Finally, we integrate the Nash-compromise within the Goodwin model. Our version of the Nash-solution replaces Goodwin's assumption of a real Phillips-curve. The proposed formulation of wage formation yields as the main conclusion that the growth cycle will disappear. The accumulation tends in the long run to a steady-state solution.

II WAGE BARGAINING: RELEVANCE AND LITERATURE

In business cycle literature and econometric simulations, it is common to model level and growth rate of wages with the Phillips-curve or with one of its modifications. To a large extent, this rather mechanical

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assumption on wage formation can be defended on empirical grounds. The Phillips-curve approach however remains ultimately a theoretical interpretation ad hoc. As an empirical construction, it has nothing to say about the process and dynamics of collective wage bargaining which precede and determine wage formation in unionized labour markets.

This black box character of wage formation was challenged by the stagflation of the seventies. Wages, real as well as nominal, did not follow the cyclical pattern as predicted by the Phillips-curve. Searching for the causes of the distributional conflicts and the wage-price dynamics of those years, macroeconomists were stimulated to explore the wage formation in a bargaining context and its interdependence with economic dynamics. Because macro-economic theory has never paid much attention to wage formation in unionized labour markets, recent research had to develop new lines of inquiry. Part of the current work in this field tries to resolve this problem by introducing elements of the bargaining theory into existing macromodels.

Economists faced the bargaining problem for the first time in connection with duopoly theory. The existence of power on both sides of the market and the relevance of bargaining elements precluded the application of the standard methods for determining prices and quantities. This indeterminacy problem was challenged in the thirties with the work of Zeuthen (1930) and Hicks (1932) on wage bargaining, and since then a lot of theories have been developed which provide determinate solutions. Nowadays, the work on bargaining forms a separate theoretical discipline.

In surveys on bargaining theory (Coddington 1968, Roth 1979, Young 1975) it is usual to distinguish two different branches.

First there are the axiomatic approaches of game theory. These formalisations do not describe the dynamics nor the process of bargaining, but instead impose or derive certain reasonable axiomas which the final outcome ought to satisfy. Key concepts are rational behaviour of the negotiators and Pareto-optimality of the outcome. The axiomatic models have been critizised for their normative character. The axiomas prescribe an outcome or enable the game theorist to predict the outcome with a certain degree of probability. But the axiomas do not have any explanatory power for the inside process of bargaining. The game solution is essentially no more than a description of the agreement which rational players will reach or a "fair" arbitrator or mediator will suggest.

The Nash-approach (1950), an early but still one of the most influential game-theoretical formalisation, is often used by economists for solving the bargaining puzzle. Later on, we will set out the Nash-solution and make use of it.

As a second branch the descriptive approaches can be distinguished. In contrast to game theory, these models are concerned with a detailed description of the actual bargaining process and its actual outcome. Well-known representatives are Zeuthen, Hicks, Pen (1950, 1952) and Cross/Coddington (1966/1968). The models differ in the nature of the specified concession-mechanisms. Each approach stresses and models different aspects of the bargaining dynamics. They all try to show the existence of a so-called convergence path: a dynamic sequence of claims and concessions resulting in a determinate agreement. Compared to game theory, these models have the flavour of describing real bargaining problems as they make use of imperfect information, expectation adjustments about the concealed aims and strategies of the other party and the manner in which parties come to concessions and treat conflict threats. However, the descriptive models can be critizised for being rather deterministic. To get a convergence path with a determinate result, just one or a few aspects of the bargaining process are identified while the further behaviour of the parties is subjected to very restrictive assumptions.

The axiomatic as well as the descriptive approaches are mostly micro formulations which assume a fixed bargaining range. From a macroeconomic point of view, this partial and static character of the bargaining literature is highly unsatisfactory. A portrayal of collective wage bargaining has to point out its interdependency with economic dynamics. By integrating bargaining theories into existing macro models, both sides can benefit; the macro-models specify the relevant bargaining range, while (elements of) the bargaining theories explain process and determinants of the wage formation.

Struggling with the difficulty how to treat power and wage stickiness in unionized labour markets, recent neoclassical theory has opted for the introduction of a monopoly-union. This approach, the socalled Monopoly-Union approach, assumes that the union monopolizes labour supply and fixes the wage rate at that level which maximises the expected collective utility of all its members, and allows the profit-maximising employers to determine the level of employment. This solution is not Pareto-optimal, however. Both the monopoly-union and the employers can improve their positions by cooperation. The determination of the resulting wage-employment combination under cooperation and the split up of the surplus income are dealt with by the Efficient-Bargaining approach. Use of elements of the bargaining theory provides unique solutions. A fruitful and realistic element of these two approaches is the introduced objective function of the union. It is not a mere wage-claimer. Instead, the union bears responsibility for the unemployed by trading off the utility gain from increased wages against the utility loss of decreased employment. Unsatisfactory is the modelling of the firms as powerless quantity-adjusters as well as the static nature of the formalisations. In order to obtain some dynamics, neoclassicals have to fall back on exogeneous random shocks. The current theory is mainly initiated by McDonald & Solow (1981). Oswald (1985) and Calmfors (1985) present surveys on the literature and the several extensions.

Apart from the neoclassical exercises within the general equilibrium approach, there are just a few and rather isolated attempts which try to describe wage bargaining within a macroeconomic setting.

Shubik (1952) and Selten & Güth (1982) choose the multiplier-accelerator model as a reference point and use the Nash-solution for the determination of income distribution. Both attempts emphasise the information aspects of the bargaining process. Shubik stresses imperfect information about the cylical situation as well as the power resources and firmness of the opponent for exploring the conditions whether or not parties can come to agreements. Selten & Güth on the other hand use the concepts of perfect information and maximal cooperative behaviour for deriving a so-called efficient wage bargaining function which for each period determines simultaneously the functional distribution and the level of national income.

Lancaster (1973) and Przeworski & Wallerstein (1982) attack the notion - especially popular under Marxists - that the basically zero-sum character of the capital-labour relation prevents any establishment of a durable class compromise on wage increments and distribution issues. Using game-theoretical approaches, they show that under certain conditions both parties can be better off with class compromises than with the adoption of militant class strategies. So cooperation and compromises on wage regulation and distribution should not be considered as irrational for realizing specific class-objectives.

Let us end this brief characterization of the literature with a final remark. Clearly, the old and current work has revealed a lot about the objectives and strategies of the negotiating parties and about the way the parties interact to obtain agreements on "wage front". Despite the recent research mentioned above, what is still missing is an adequate approach for modelling the interdependence of collective wage bargaining and macroeconomic dynamics. This paper has to be viewed as an attempt to provide a contribution in this direction. As stated before we set out an integration of the Nash solution with the cyclical-growth model of Goodwin.

III THE GOODWIN MODEL

Goodwin derives a self-sustained growth cycle from the key-assumptions that wage formation and distribution depend on the employment rate, while the profit rate determines the growth rate of accumulation.

The purpose here is first to set out the Goodwin model and its dynamics, and second to give a comment on the way wage formation is reflected. The exposition is in difference equations (compare Glombowski & Krüger 1984); all variables are real and net.

Employment L is determined by the labour productivity y and the level of income Y:

(1) $L_t = Y_t/y_t$

Technical progress is neutral in the sense of Harrod; so labour productivity is rising at a constant rate of growth m,

(2) $y_{t+1}/y_t = 1 + m$

while the output-capital ratio k remains constant:

(3) $k = Y_t/K_t.$

K denotes the capital stock.
Supply of labour N expands with a constant growth rate n:

(4) $N_{t+1}/N_t = 1 + n$

Workers do not save and consume the whole wage income. With w as the real wage rate, actual profits P can be expressed as:

(5) $P_t = Y_t - w_t L_t$

The combination of (1) and (5) gives an expression for the wage share in income λ:

(6) $\lambda_t = w_t/y_t$

The growth factor of the wage share is obtained by dividing the growth factor of the real wage rate by the growth factor of labour productivity:

$$\frac{\lambda_{t+1}}{\lambda_t} = \frac{w_{t+1}/w_t}{y_{t+1}/y_t}$$

Using the empirical observation that the real wage rate rises in the neighbourhood of full employment, Goodwin relates the growth factor of real wages to the actual employment rate β. The latter is the ratio of employment to labour supply:

$$(7) \qquad \beta_t = L_t/N_t$$

Without loss of the essence, the discrete variant keeps the elegance of Goodwin's original formulation in differential terms if the rate of employment determines the relative change in the wage share:

$$(8) \qquad \frac{\lambda_{t+1}}{\lambda_t} = -a_1 + a_2\beta_t$$

Equation (8) can be interpreted as a linear and real approximation of the original Phillips-curve.

Finally, the accumulation process has to be specified. The capitalists can only make use of realized profits for the financing of investments. It is assumed that the capitalists spend a constant fraction d of profits on investments, ΔK. The other part is consumed.

$$(9) \qquad \Delta K_t = dP_t$$

With (3), (5), (6) and (9) the growth rate of the accumulation can be stated as:

$$(10) \qquad \frac{\Delta K_t}{K_t} = \frac{dP_t}{K_t} = dk(1-\lambda_t)$$

Because of the constancy of d and k, fluctuations in the accumulation rate are wholly determined by the profit share. Note that the model excludes realization problems: production always equals income and demand.

(1)-(10) determine a cyclical growth process around the steady-state growth rate n+m, where fluctuations in the accumulation rate arise from the interaction of the wage share and the employment rate. The model can be reduced to two difference equations in the two variables β and λ.

With respect to the wage share, equation (8) simply can be used. The derivation of the expression for the employment rate requires some steps. After rewriting (7) as

$$(11)\qquad \frac{\beta_{t+1}}{\beta_t} = \frac{L_{t+1}/L_t}{N_{t+1}/N_t}$$

and inserting (1)-(4), (6) and (10) in (11), we obtain the desired expression:

$$(12)\qquad \frac{\beta_{t+1}}{\beta_t} = a_o - b_o\lambda_t$$

with

$$a_o = \frac{(1+dk)}{(1+n)(1+m)} \qquad \text{and } b_0 = \frac{dk}{(1+n)(1+m)}$$

The reduced version of the model in (8) and (12) can also be written as the following system:

$$(13)\qquad \frac{\Delta\lambda_t}{\lambda_t} = a_2\beta_{t+1} - (a_1+1)$$

$$(14)\qquad \frac{\Delta\beta_t}{\beta_t} = (a_o-1) - b_o\lambda_t$$

What are the properties of this system?
A steady-state growth path is reached when

$$(15)\qquad \Delta\lambda_t = \Delta\beta_t = 0$$

(13)-(15) together determine the equilibrium values for β and λ

$$(16)\qquad \lambda_e = \frac{(a_o-1)}{b_o}$$

$$(17)\qquad \beta_e = \frac{(a_1+1)}{a_2}$$

This equilibrium point is locally stable. In geometrical terms this will say that in a (β,λ)-plane the point (β_e,λ_e) is a center surrounded by a closed curve (compare fig. 1). This curve summarizes the duration and pattern of one Goodwin cycle. The position and the amplitude of cycle are determined by the initial values for β and λ.
Rewriting (13) and (14) in terms of their equilibrium values yields:

(18) $\Delta\lambda_t/\lambda_t = a_2(\beta_{t+1}-\beta_e)$

(19) $\Delta\beta_t/\beta_t = b_o(\lambda_e-\lambda_t)$

Now, it is quite easy to determine the direction of both variables in the regions I-IV

(20) $\Delta\lambda_t/\lambda_t \gtreqless 0 \Rightarrow \beta_{t+1} \gtreqless \beta_e$; $\Delta\beta_t/\beta_t \gtreqless 0 \Rightarrow \lambda_t \lesseqgtr \lambda_e$

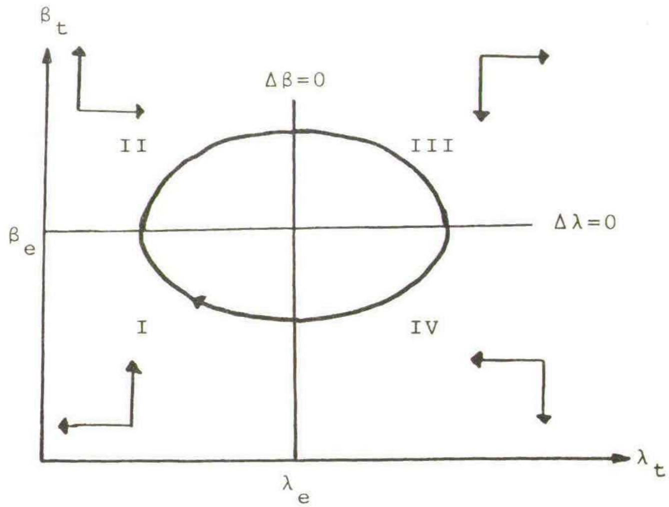

FIGURE 1

The dynamics of the discrete variant of Goodwin's model and its geometrical representation need a comment. Unlike Goodwin's model, in the discrete version β and λ are not determined simultaneously. As the system (13) and (14) shows, their interdependency is split up in time. The income distribution in t determines accumulation and employment in t+1, while the resulting employment rate in t+1 is the determining factor for the income distribution in t+1.

The growth cycle consists out of four phases. It can be described as follows. At the border of region IV and I, the employment is below its average value, so the rate of growth of the real wage is less than the rise in the labour productivity. Therefore, profit share and profit rate are rising, pushing up the accumulation rate above its average value. The profit share and the growth rate of the accumulation arrive their maximum values when the employment ratio reaches its average value. From this moment on, phase II is actual. Although the accumulation rate still exceeds the equilibrium rate of growth, this rate will decelerate because the rising employment ration enables the labour force to bargain for real wage increases in excess of the rise in labour productivity. Subsequently, the profit share is reduced and is going to approach its average value. This profit squeeze continues in phase III where the accumulation rate is below average but the employment ratio, although decreasing, still exceeds its equilibrium level. With the entering of phase IV, the profit share and the profit rate recover. When initial conditions are restored, the described dynamics restart.

Taking a long run view, this self-sustaining dynamic process with its trade off between employment and distribution can be interpreted as a formal description of a part of the recent history of the capitalist accumulation. Using Goodwin's words, this explanation runs as follows: " ... [an] improved profitability carries the seed of its own destruction by engendering a too vigorous expansion of output and employment, thus destroying the reserve army of labour and strengthening labour's bargaining power" (Goodwin 1967, p. 169).

Despite its flavour describing reality, the model suffers from too much automatism. Apart from the manner capitalists take their accumulation decisions, this concerns the rather mechanical wage regulation through a real version of the Phillips-curve. This way of modelling wages presupposes that class power is ultimately the decisive factor on the labour market. In modern capitalism however, wage formation is by and large arranged by collective bargaining agreements. These agreements reflect compromise rather than conflict. Unions are more than mere wage-claimers. Feeling themselves responsible for durable employment of the labour population, they keep an eye on current and future profit development and may moderate their wage claims when necessary. Capitalists, taking care for the profitability of their long term investments, strive for loyal workers and rest and stability on the "wage front". Their objectives can be better off if they consent with reasonable wage claims. This kind of attitudes contrast with a strictly zero-sum interpretation of distribution issues as implied by a model of class conflict. However, collective bargaining resulting in distribution compromises need not to exclude the relevance of class power. This relevance however has to be demonstrated, and not just be assumed.

The Goodwin model may benefit if the black-box character of the wage formation can be superseded through an introduction of bargaining elements. This extension may enlarge the realism of the model. And moreover, an explication of the bargaining process can illustrate aims and strategies of the parties and the conditions for consensus and conflict on distribution issues either.

A logical way to handle this issue seems to be the replacement of equation (8) by a bargaining model. The next paragraph is adressed at the derivation of such a bargaining model. As stated before, we will make use of the Nash-solution.

IV BARGAINING RANGE AND THE NASH-SOLUTION

IVa THE NASH-SOLUTION OF THE BARGAINING PUZZLE

Nash (1950) puts the bargaining problem in utility terms and treats it as a non-zero-sum fixed-threat game. With fixed threat is meant that both parties always have the possibility to choose a situation of conflict rather than to procede with bargaining. The game is a non-zero-sum one because the utility of every agreement exceeds the (zero-)utility of the conflict situation. The parties order the several agreements in terms of the utility increments with respect to the threat point. The frontier of the relevant bargaining range can be reflected with an Edgeworth-contractcurve, like the curve CC in fig. 2. This curve is the locus of all the situations where one party can augment its utility only

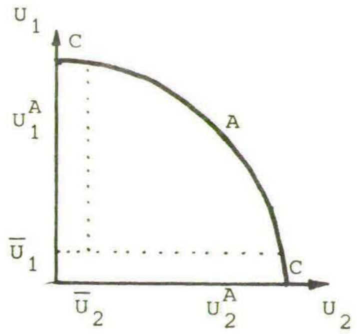

FIGURE 2

at the expense of the opponent. As long as the parties are moving into the direction of the contract curve, their interests need not to be necessarily contradictory. The parties have collected and ordered all the relevant information in an utility preference function.

Next, Nash formulates four axiomas which prescribe an unique solution for this game:

Pareto-optimality: the solution has to be an element of the utility frontier;

Symmetry: the parties have identical utility functions;

Transformation invariance: if the absolute utility values change but not the preferred ordering, then the final outcome undergoes no change;

Independence of irrelevant alternatives: if the preferred ordening of the outcomes changes except with respect to the solution point, then the game result will not change.

What Nash has proved is that this set of axiomas determines only one solution of the game, namely point A on the contractcurve. At this point, the product of the utility increments of both parties is maximal:

$$(U_1^A-\bar{U}_1)(U_2^A-\bar{U}_2) = \text{Max.}$$

In this expression $\bar{U}_1$ and $\bar{U}_2$ stand for the players' conflict utilities, while U_1^A and U_2^A denote utilities of the game solution.
(The game-theoretical literature provides numerous more comprehensive treatments of the Nash-solution; compare Harsanyi (1956), Roth (1979)).

IVb A SOLUTION FOR THE BARGAINING INDETERMINACY IN A DYNAMIC SETTING

It is assumed that a bargaining income arises at the end of every period. This income is divided among workers and capitalists within the Nash-method. The bargaining income R_t results out the net added value Y_t after deduction of provisional wage costs w_tL_t and provisional profits, rK_t. With 'provisional' is meant that at the beginning of the period the parties agree on a temporary wage rate w, and a temporary profit rate r. These ex ante yields are paid during the production period. The provisional profit rate is assumed to be constant.
The resulting bargaining range can now be expressed as:

(1) $$R_t = Y_t - w_tL_t - rK_t$$

At the end of the production period, the parties have to achieve an agreement on the distribution of this surplus income. The definite yields for labour and capital result from the agreed division. The ex post wage rate is denoted by ω, while π represents the ex post profit rate. A complete division of the bargaining income is achieved when:

(2) $$R_t = (\omega_t - w_t)L_t + (\pi_t - r)K_t$$

The parties come to an agreement by means of the Nash-method.
Workers use as utility function:

(3) $$U_w = \alpha(\omega - w)^a$$

and the capitalists:

(4) $$U_k = \varepsilon(\pi - r)^b$$

Because K and L as well as w and r are known at the end of the production period the actual stake of the bargain is income maximalisation. Analogous to Nash, parties strive for a division which maximises the product of their utilities.

With (2)-(4) the following Lagrange function can be derived with the Lagrange-multiplicator μ:

$$(5) \qquad V = \alpha\varepsilon(\omega - w)^a \; (\pi - r)^b \; - \; \mu[R-(\omega-w)L-(\pi-r)K]$$

A Pareto-optimal division arises when (5) is differentiated to ω, π and μ, and the obtained results are equalized to zero:

$$(6) \qquad \frac{\partial V}{\partial \omega} = a\alpha\varepsilon(\omega-w)^{a-1} \; (\pi-r)^b \; + \mu L = 0$$

$$(7) \qquad \frac{\partial V}{\partial \pi} = b\alpha\varepsilon(\omega-w)^a \; (\pi-r)^{b-1} \; + \mu K = 0$$

$$(8) \qquad \frac{\partial V}{\partial \mu} = (\omega-w)L + (\pi-r)K - R = 0$$

With (8) and after elimination of the μ-term, (6) and (7) provide expressions of the Nash-dividends for the workers and the capitalists:

$$(9) \qquad \omega - w = \frac{aR}{(a+b)L}$$

$$(10) \qquad \pi - r = \frac{bR}{(a+b)K}$$

Apart from the division of the revenue-income in the current period, one has to explain how parties agree on the provisional wage rate for the coming period. The periodical increment of the ex ante wage rate is assumed to follow quasi-automatically the difference between the ex post and ex ante wage rates of the preceding period:

$$(11) \qquad w_{t+1} - w_t = j(\omega_t - w_t)$$

Now, this solution for the bargaining process is integrated within a relative simple accumulation model. This model is a stripped version of Goodwin's: here, the relevance of the labour market and class power for wage formation has been omitted. Before dealing with a Goodwin-plus-Nash model, some dynamics of the stated formalisation of the Nash-solution should be illustrated.

(12) $Y_t = kK_t$

(13) $L_t = Y_t/L_t$

(14) $y_{t+1}/y_t = 1 + m$

(15) $K_{t+1} = (1+d\pi_t)K_t$

Capital stock K and the constant capital productivity k determine the net-product Y (12). Employment depends on labour productivity y and net-product (13). Labour productivity rises with a constant rate m (14). Capitalists invest a constant fraction d of realized profits (15).

(1), (9)-(11) and (12)-(15) constitute together a complete model of eight equations in eight unknowns: R, Y, w, K, L, Y, ω and π. The model has a stable steady-state solution. It can be reduced into one single equation in the (ex ante) wage share.
Starting with inserting (9) into (11):

(16) $$w_{t+1}-w_t = \frac{aj}{a+b}\cdot\frac{R_t}{L_t}$$

L and R can be described as functions of k and y: L by means of (12) and (13); R through (1), (12) and (13). Substituting the results in (16) yields:

(17) $$w_{t+1}-w_t = \frac{aj}{a+b}\cdot\frac{k(1-w_t/y_t) - r}{k/y_t}$$

The ex ante wage share λ reads as:

(18) $$\lambda_t = \frac{w_tL_t}{Y_t}$$

Note that this λ is not the same as the one used in par. II. Here λ has to be interpreted as the wage share at the end of the production period but before the distribution of the revenue.

Inserting (18) in a rearranged (17) gives:

$$(19) \qquad \frac{w_{t+1}}{w_t} = 1 + \frac{aj}{a+b} \cdot \frac{(1-\lambda_t - r/k)}{\lambda_t}$$

An expression for the growth factor of the ex ante wage share is found with (14) and (18):

$$(20) \qquad \frac{\lambda_{t+1}}{\lambda_t} = \frac{w_{t+1}}{w_t} \cdot \frac{1}{1+m}$$

Next, combining (19) and (20), the difference-equation in λ can be derived:

$$(21) \qquad \frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{1+m} + \frac{aj(1-\lambda_t - r/k)}{(1+m)\ (a+b)\lambda_t}$$

The wage share reaches its equilibrium value if $\lambda_{t+1}/\lambda_t = 1$:

$$(22) \qquad \lambda_e = \frac{aj(1-r/k)}{aj+m(a+b)}$$

Putting (22) in (21) provides:

$$(23) \qquad \frac{\lambda_{t+1}}{\lambda_t} = \frac{(a+b)-aj}{(1+m)\ (a+b)} + \frac{aj+m(a+b)}{(1+m)\ (a+b)} \cdot \frac{\lambda_e}{\lambda_t}$$

This expression shows that

$$(24) \qquad \lambda_t \gtreqless \lambda_e \Rightarrow \lambda_{t+1} \lesseqgtr \lambda_t$$

So, the equilibrium value λ_e is asymptomatically stable (compare figure 3).

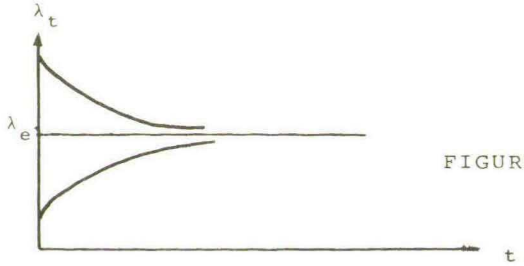

FIGURE 3

Constancy of the wage share as the steady-state solution implies long-run constancy of the other endogeneous variables. Steady-state growth requires an increase of the ex ante wage rate in accordance with the constant growth rate of labour productivity. Because of (11), the steady-state growth path of the ex post wage rate can be written as:

$$\omega_t = (1+m/j)w_t \tag{25}$$

Thus, ex post wage rate always exceeds ex ante wage rate, both having same rates of growth. Therefore, in the long run ex post wage share is constant too and so ex post profit rate either. A fixed profit rate implies constant growth factors for accumulation and production:

$$\frac{K_{t+1}}{K_t} = \frac{Y_{t+1}}{Y_t} = 1 + d\pi_e \tag{26}$$

and for employment:

$$\frac{L_{t+1}}{L_t} = \frac{1+d\pi_e}{1+m} \tag{27}$$

Finally, the relative bargaining range R/Y also remains constant:

$$\frac{R}{Y} = 1 - \lambda_e - r/k \tag{28}$$

Note that equilibrium values of income shares are not influenced by the accumulationquote d. Unlike Goodwin, any relationship between wage formation and employment is absent. The resulting distribution is completely determined by the "fair" division of the Nash-method.

We illustrate the Nash-solution with some figures. Following Nash, there has to be symmetry between the parties: a=b=1. Mutual confidence and cooperative intentions are maximal: r=0, d=1 and j=1. Therefore, no guarantee for a positive ex post profit rate exits, capitalists accumulate realized profits completely and the new ex ante wage rate is identical with the old ex post wage rate. Given the values of the technological variables, the following expressions for the equilibrium values of the wage share, profit share and relative bargaining range result:

(29) $\lambda_e = 1/(1+2m)$

(30) $\pi_e = mk/(1+2m)$

(31) $(R/Y)_e = 2m/(1+2m)$

Because revenue income is always divided in two identical parts as wage and profit income, the symmetry of the solution is complete:

(32) $(\omega-w)L = (\pi-r)K$

Some aspects of this solution for the puzzle of the bargaining indeterminacy can now be discussed. Clearly, choosing the approach of Nash, any description of how parties come to an agreement on distribution issues is excluded. The model only points out that whenever the parties intent to compromise as well as to cooperate they may overcome the inherent conflict character of distribution by accepting the specific class preferences of the opponent. By granting the mutual income claims, parties not only realize the preferred distribution outcome, moreover they eliminate distribution conflicts as a main source of economic instability. As such, the model highlights one of the conditions for a durable economic equilibrium.

To derive a determinate solution, one need not to rely on the frequently used assumptions within game theory of perfect forsight and rational expectations. The tendency to steady-state is virtually a periodical sequence of local Nash solutions. This result entails the 'pretty' possibility of returning to the reality of fluctuating growth again. A starting point may be found in a relaxation of the constancy of the Nash-dividends.

Such a relaxation can be achieved by an explicite integration of information aspects. When perfect forsight is absent, the negotiating parties suffer from a constrained ability to take full account of the consequences of current agreements for the income shares in the following periods. Therefore, it is rather plausible to assume that changing economic conditions will be reflected in changing class preferences and utility functions. These recurrent adjustments in the Nash-dividends may prohibit the carrying-on of the steady-state tendency.

This line of inquiry is not explored in the present paper. Variable Nash-dividends can also be achieved by including elements of class power. This is the subject of the next paragraph in which the Nash-solution is integrated within a Goodwin like accumulation model.

A GOODWIN-NASH MODEL

The proposed Goodwin-Nash model is a mixture of cooperation and class power elements. The model consists out of twelve equations. After the foregoing, the first seven need no comment anymore:

(1) $L_t = Y_t/y_t$

(2) $y_{t+1}/y_t = 1+m$

(3) $N_{t+1}/N_t = 1+n$

(4) $k = Y_t/K_t$

(5) $\beta_t = L_t/N_t$

(6) $\lambda_t = w_t/y_t$

(7) $K_{t+1}/K_t = 1+d\pi_t$

The regulation of wage formation and distribution by a real Phillipscurve in Goodwin's model is replaced by the Nash bargaining model. Here, only the relevant equations of the Nash-solution are presented:

(8) $R_t = Y_t - w_tL_t - rK_t$

(9) $\omega_t - w_t = \frac{a}{a+b} \cdot \frac{1-\lambda_t - r/k}{\lambda_t}$

(10) $\pi_t - r = \frac{b}{a+b} [k(1-\lambda_t)-r]$

(11) $w_{t+1} - w_t = j_t(\omega_t - w_t)$

Goodwin's significance of scarcity and class power on the labour market for wage formation and distribution is regained by assuming that the determination of ex ante wage rate for the following period is based on the actual ex post bargaining result as well as the actual employment ratio:

(12) $j_t = h\beta_t$

When the employment rate is above average, capitalists have to accept a relative high ex ante wage rate formation in order to prevent workers falling back on a Goodwin like open class conflict strategy. In the opposite case, when the degree of employment is relatively low, workers moderate their ex ante wage claims surpressing the capitalists' inclination towards the return to the hard world of Goodwin.

The model has twelve equations and twelve unknowns: Y, y, L, N, K, R, j, w, ω, π, β, λ. It can be reduced to two difference equations in β and λ.

Combining (9), (11) and (12), we obtain:

(13) $$w_{t+1}-w_t = \frac{ha}{a+b}.\frac{1-\lambda_t-r/k}{\lambda_t}.\beta_t$$

With help of the following identity:

(14) $$\frac{\lambda_{t+1}}{\lambda_t} = \frac{w_{t+1}}{w_t}.\frac{1}{1+m}$$

(13) can be rewritten as:

(15) $$\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{1+m} + \frac{1}{1+m}.\frac{ha}{a+b}.\frac{1-\lambda_t-r/k}{\lambda_t}.\beta_t$$

This is the first one of the two difference equations.

The second is obtained as follows:

(5) can be restated as

(16) $$\frac{\beta_{t+1}}{\beta_t} = \frac{L_{t+1}/L_t}{N_{t+1}/N_t}$$

Next, (1)-(3) and (7) are inserted:

(17) $$\frac{\beta_{t+1}}{\beta_t} = \frac{1+d\pi_t}{1+g}$$

with

(18) $$1+g = (1+n)\ (1+m)$$

Use of (10) gives finally the second equation in β and λ.

(19) $$\frac{\beta_{t+1}}{\beta_t} = \frac{1 + d\{r+\frac{b}{a+b}\ [k(1-\lambda_t)-r]\}}{1+g}$$

The equilibrium solution of system (15) and (19) has as relevant properties, that investment and ex post profits expand with the natural growth rate g, while wage share and employment rate remain constant. The equilibrium values of λ and β can be found with $\beta_{t+1}/\beta_t = 1$ respectively $\lambda_{t+1}/\lambda_t = 1$:

$$(20) \qquad \lambda_e = 1 - \frac{a+b}{bk}(g/d-r) - r/k$$

$$(21) \qquad \beta_e = \frac{m(a+b)}{ha} \cdot \frac{\lambda_e}{1-\lambda_e-r/k}$$

Now, we can show that in the long run the Goodwin-Nash dynamics tends to a stable steady-state solution with the above stated properties.
We start with the derivation of the two loci including all the (β,λ)-combinations for which either $\lambda_{t+1}/\lambda_t = 1$ or $\beta_{t+1}/\beta_t = 1$.

The determination of the locus $\beta_{t+1}/\beta_t = 1$ is relatively easy. We can make use of the expression for λ_e:

$$(22) \qquad \lambda_t = \lambda_e \Rightarrow \beta_{t+1}/\beta_t = 1$$

Consider equation (19). Size and direction of the periodical change in the employment rate is determined by the ratio between the actual wage share and its equilibrium value:

$$(23) \qquad \lambda_t \gtreqless \lambda_e \Rightarrow \beta_{t+1} \lesseqgtr \beta_t$$

In order to obtain the locus of $\lambda_{t+1}/\lambda_t = 1$ we define a partial equilibrium function ψ:

$$(24) \qquad \lambda_{t+1}/\lambda_t = \psi(\beta_t,\lambda_t) = 1$$

After inserting (15), we obtain:

$$(25) \qquad \beta_t = \frac{m(a+b)}{ah} \frac{\lambda_t}{1-\lambda_t-r/k}$$

Only $1-\lambda_t-r/k > 0$ is relevant:

$$(26) \qquad 0 < \lambda < \lambda^* \qquad \text{with } \lambda^* = 1 - r/k$$

The relevant properties of (25) are the following:

$$\beta_t(0) = 0 \qquad \beta_t(\lambda^*) = \infty$$

(27)

$$\partial\beta_t/\partial\lambda_t > 0 \qquad \partial^2\beta_t/\partial\lambda^2_t > 0$$

Furthermore, it is clear that

(28) $$\beta_t \gtreqless \psi \Rightarrow \lambda_{t+1} \gtreqless \lambda_t$$

Loci and directions of the periodical changes in β and λ can be represented geometrically with figure 4.

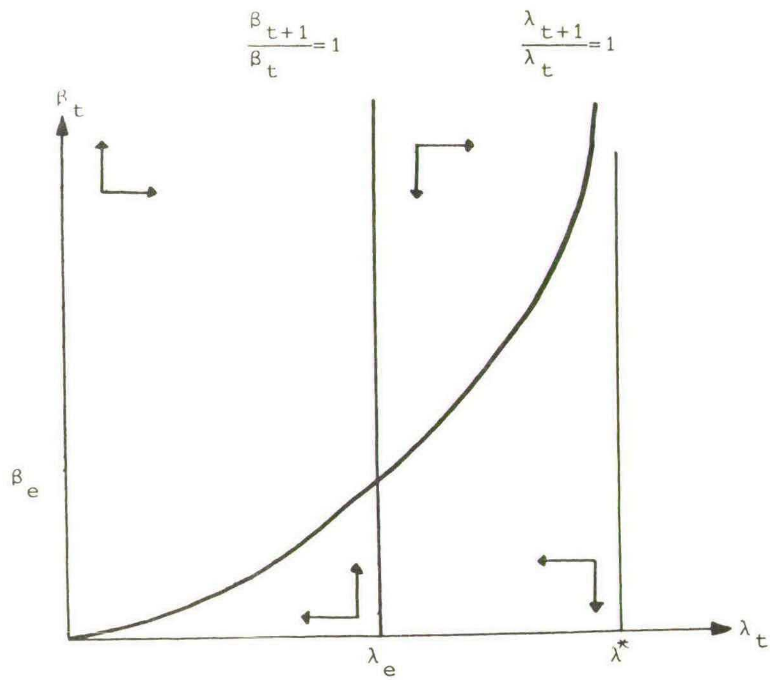

FIGURE 4

As to the dynamic behaviour of the Goodwin-Nash model consider the Jacobian of the system (15) and (19), linearized around its equilibrium, i.e.

$$J = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

where

$A = 0$

$$B = - \frac{kbd}{(a+b)\ (1+g)}$$

$$C = \frac{ha}{(a+b)\ (1+m)} \frac{1-\lambda_e-r/k}{\lambda_e}$$

$$D = - \frac{ha}{(a+b)(1+m)} \frac{1-r/k}{\lambda_e^2} \beta_e$$

Evaluation of the Jacobian yields that the equilibrium solution is a stable node: i.e. wherever the system starts, there always results a damped oscillatory and stable movement towards the equilibrium solution (compare figure 5). $A = 0$, $B < 0$, $C > 0$ and $D < 0$ imply that the eigenvalues are a complex pair (oscillations) and have a negative real part (stability).
This weak and diminishing cyclical movement towards an equilibrium steady-state solution ultimately means that "Nash" is more dominant than "Goodwin". The influence of the employment rate on the ex ante wage formation is completely overruled by the fair division of the resulting revenue income.

In order to clarify the dynamical process and the equilibrium solution, we compare and comment upon tow cases. Case 1 reflects a situation where the willingness of the parties to cooperate and to consent is great; both parties have much confidence in the opponent's willingness to act in accordance with the agreed compromise. Within case 2, parties confidence in a durable compromise on distribution issues is small. Because of mutual

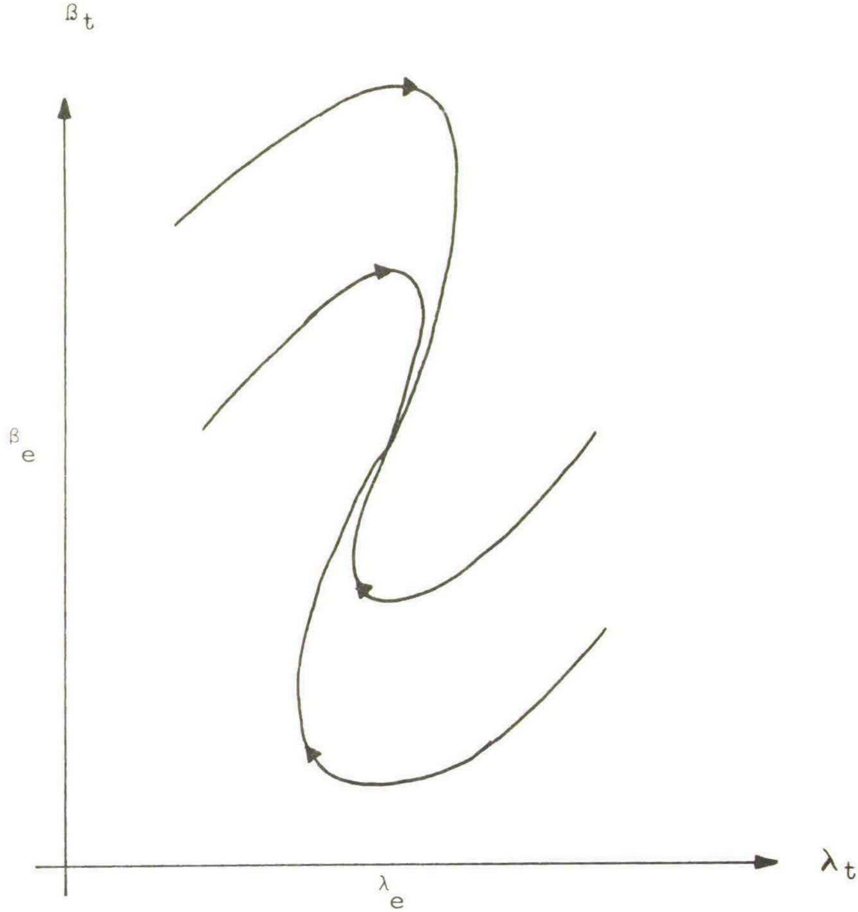

FIGURE 5

distrust, both parties force some a priori certainty by claiming a high provisional wage rate and a high provisional profit rate during the production period. Chosen figures are such that both cases have the same equilibrium values. Start values are indicated with β_s and λ_s.

Table 1

EX ANTE CLAIMS AND EX POST RESULTS

$a = b = 1$ $m = 0,04$ $\beta_s = 0,8$ $\lambda_s = 0,8$ $k = 1/3$ $g = 0,05$	
CASE 1	CASE 2
BARGAINING PARAMETERS	BARGAINING PARAMETERS
$d = 1$ $h = 0,2074$	$d = 2/3$ $h = 0,4148$
$r = 0$	$r = 0,05$
EQUILIBRIUM VALUES	EQUILIBRIUM VALUES
$\lambda_e = 0,7000$ $\pi_e = 0,05$	$\lambda_e = 0,7000$ $\pi_e = 0,075$
$\beta_e = 0,9000$	$\beta_e = 0,9000$

The figures show that the size of the bargaining parameters do not have any influence at all on the basic pattern of the adjustment process towards the equilibrium point. The adjustment process itself can be subdivided into two parts.

Short run dynamics are dominated by a relatively fast movement of wage and profit shares towards their equilibrium values. The Nash-component of the compromise within the proposed Goodwin-Nash model is such a strong equilibrating force that the potential significance of the employment component for distribution and wage formation is negligible in the short run. Virtually, by acting within the confines of the compromise, parties attach more value at reaching the agreed distribution at any level of income, than at the resulting level of income and employment.

When distribution corresponds with the agreement, labour and product markets will restore themselves from their preceding subordinated role. From this moment on, the system will exhibit some Goodwin like dynamics. However, unlike Goodwin's model, these dynamics are stabilizing of nature. Key variable in this process is the employment rate. Because this rate is still far away from its equilibrium value, the ex ante wage forma-

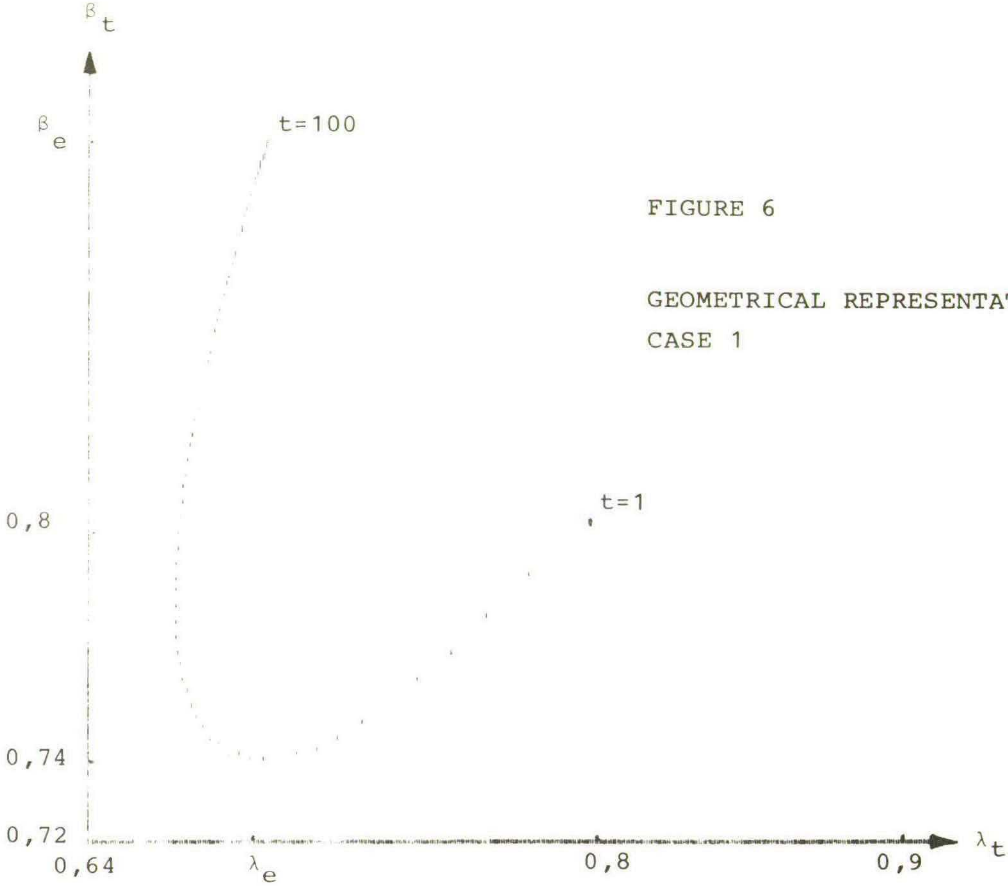

FIGURE 6

GEOMETRICAL REPRESENTATION
CASE 1

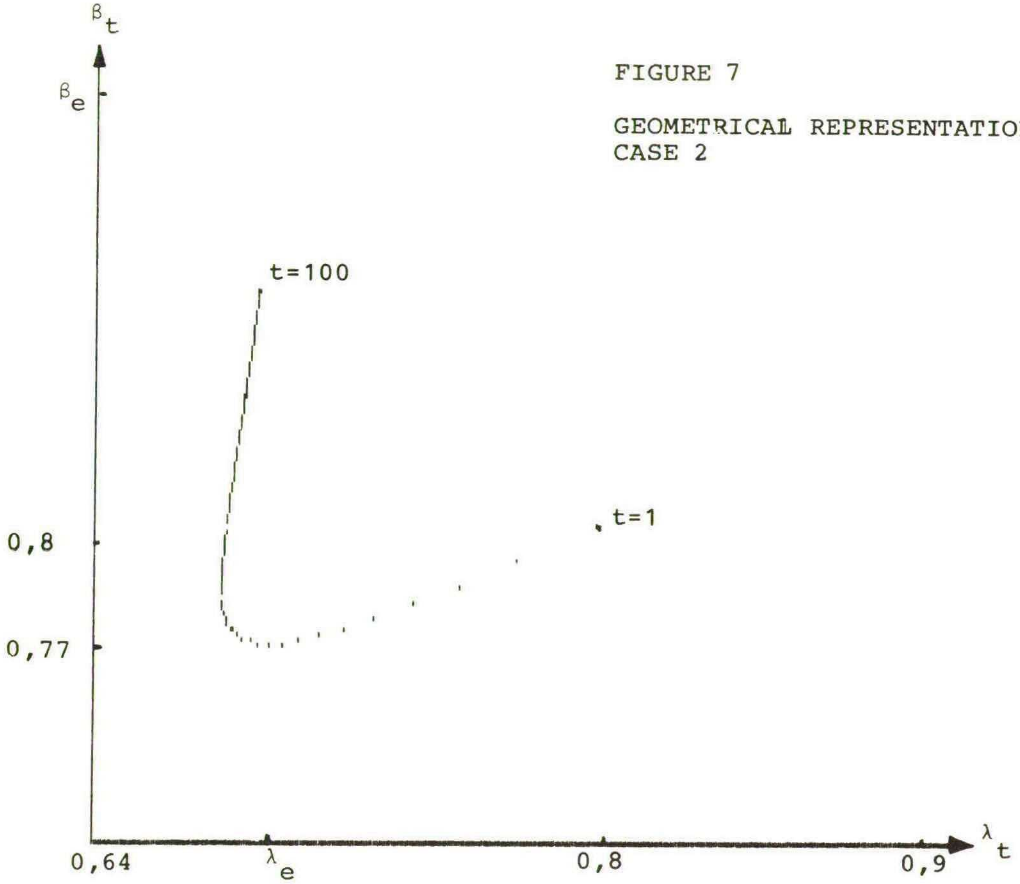

FIGURE 7

GEOMETRICAL REPRESENTATION
CASE 2

tion will diverge from the steady-state wage formation. This gap in the wage formation stands in inversed proportion to the gap in the employment rate. The recurrent wage gaps force a temporary walk away of the revenue income and the distribution from their equilibrium values until the resulting changes in the accumulation rate have lead to an adjustment of the employment rate to its steady-state value.

It is now time to compare the two cases. Looking at the values of β and λ at the turning points, and at the moment when these points are reached, clarifies that the more cooperative the parties are, the slower the short run dynamics react and the larger the created disequilibrium on the labour and product market is which the long run adjustment process has to overcome. This paradoxical result can be explained as follows. The periodical change in the ex ante wage rate is determined by the ex post wage rate and employment rate of the preceding period:

(29) $$w_{t+1}-w_t = h\beta_t(\omega_t-w_t)$$

When parties are more cooperative, h will be smaller. Therefore, the short run adjustment in the employment rate has to be greater in order to produce the necessary accomodations in the ex ante wage rate and ex ante distribution that will lead to the establising of the fair distribution. Depending on the size of the start values, a very disciplined attitude of one or both of the two parties is required during the adjustment process. In the presented cases, it concerns the workers. The realization of the compromise in the long run requires that they consent with a temporary reduction of the employment rate as well as the wage share. This can be viewed as an illustration of the strategy dilemma in which the unions were recently involved, and still are: whether to opt for a defence of current wage income and consumption at the cost of future wages and employment because of the continuation of the profit squeeze, or to strive for durable employment and consumption in the future by way of moderate current wage claims in the expectation that the capitalists will invest a sufficient part of the resulting surplus profits to bring forth the desired level and growth of employment and wages.

In both cases, the final stage in the adjustment process is very lengthy, because the revenue income and the relative bargaining range R/Y remain in the neighbourhood of their equilibrium values:

(30) $(R/Y)_e = 1 - \lambda_e - r/k$

This altogether emphazises even more the dominance of Nash over Goodwin.

Now, we comment on the steady-state solution itself by extending the model with some other game-theoretical elements.

Suppose the game is dynamic. At the beginning of period t=1, parties have to decide on the value of the bargaining parameters. Both parties dispose over one degree of freedom. Capitalists fix the provisional profit rate r and workers determine the size of h. Workers aim at a high expost wage rate, while capitalists strive for a high ex post profit rate. None of the parties is able to trace the long run effects of specific values and combinations of h and r on the class-objectives. Mutual confidence determines how far the parties will cooperate.

When mutual confidence decreases, it seems rational for the parties to claim more (ex ante) certainty about the (ex post) values of their objective variables. At any rate of employment, workers will be more militant and opt for a high h, while rational capitalists will try to reduce their uncertainty about ex post profitibality by claiming a higher ex ante profit rate r. When mutual confidence increases, parties will make the opposite choices.

A remarkable result of this game is that the choices of the parties have no influence at all on the equilibrium values of their aims. Moreover, when the employment rate and the wage and profit shares are considered too, one gets the striking outcome that short term rationality will even lead to irrationality in the long run. This can be illustrated by changing the values of h and r within case 2.

TABLE 2

CHANGES IN h AND r: EX POST EFFECTS

CONSTANTS								
a=1	b=1	m=0,04	g=0,05	d=2/3	k=1/3			
h					r			
h	0,4	0,4148	0,42		h	0,4148	0,4148	0,4148
r	0,05	0,05	0,05		r	0,06	0,05	0,04
λ_e	0,7000	0,7000	0,7000		λ_e	0,7300	0,7000	0,67
β_e	0,9333	0,9000	0,8888		β_e	1,5600	0,9000	0,6153
π_e	0,075	0,075	0,075		π_e	0,075	0,075	0,075
je	0,3733	0,3733	0,3733		je	0,6471	0,3733	0,2552

Given the capitalist option for a specific r, the workers can influence neither level and growth path of the ex post wage rate (j_e) nor income distribution. The opted strategy however does affect the employment rate: greater (less) militancy leads to a smaller (greater) employment rate. The effects of the choice made by capitalists can be described in a similar manner. The claimed ex ante profit rate does not influence the ex post profit rate. Paradoxically, only workers benefit from a rise in r: they are furnished with more certainty because the ex ante income distribution as well as the ex ante wage rate are raised, and moreover the employment rate will rise too.

The effects of mutations in h and r for the values of β_e and λ_e can be read off from their already known expressions:

$$\lambda_e = 1 - \frac{a+b}{bk}\,(g/d-r) - r/k$$

$$\beta_e = \frac{m(a+b)}{ah}\cdot\frac{\lambda_e}{1-\lambda_e-r/k}$$

As concerns the objective of the workers, the consequences of the claimed ex ante yield can be clarified with the steady-state growth path for the ex post wage rate:

$$(31) \qquad \omega_t = (1+m/j_e)w_t$$

with

$$(32) \qquad j_e = h\beta_e = \frac{m(a+b)}{b} \cdot \frac{\lambda_e}{1-\lambda_e-r/k}$$

Thus, workers have only influence on the employment rate. However, "Nash" dominates "Goodwin". Therefore, the fair division of the revenue income completely subordinates the potential significance of the employment rate for distribution and wage formation. All distribution issues are controlled by capitalists. This concerns the size of the income shares as well as the growth rates of the ex ante and the ex post wage rates. The ex post profit rate however remains surprisingly unaffected by the choices both parties make for specific values of the strategy variables, h and r. Inserting the expression of λ_e in equation (10), the Goodwin-Nash dividend for the profit rate, yields:

$$(33) \qquad \pi_e = g/d$$

The natural growth rate is given, so only the accumulationquote d determines the steady-state value of the expost profit rate. This final result has a postkeynesian flavour. A self-sustained steady-state exists only on the conditions that the investments expand with the fixed natural growth rate, and that the savings provides the finance for these investments. Only capitalists save. Thus, they determine with the size of their savings ratio (our variable d) the steady-state proportion between profits and investments, which guarantees the equality of savings and investments. Therefore, they fix each steady-state period the levels of income and employment as well as the functional income distribution.

Table 3 summarizes some effects of mutations of d for the equilibrium values of the relevant variables.

TABLE 3

CHANGES IN d: EX POST EFFECTS

CONSTANT		
$a = b = 1$	$m = 0{,}04$	$h = 0{,}4148$
$k = 1/3$	$g = 0{,}05$	$r = 0{,}05$
$d = 0{,}65$	$d = 0{,}6667$	$d = 0{,}68$
$\beta_e = 0{,}8218$ $\lambda_e = 0{,}6884$ $\pi_e = 0{,}0769$	$\beta_e = 0{,}9000$ $\lambda_e = 0{,}7000$ $\pi_e = 0{,}075$	$\beta_e = 0{,}9682$ $\lambda_e = 0{,}7088$ $\pi_e = 0{,}0735$

Therefore, it can finally be concluded that a durable class-compromise on distribution issues within the Goodwin-Nash model requires first moderate ex ante wage and profit claims and second a high accumulation quote.

VI SUMMARY

In this paper aspects of the relationship between collective wage bargaining and business cycles have been discussed. We started with some shortcomings of the usual representation of wage formation in macroeconomic literature on cycles and accumulation; usually, elements of the wage bargaining process are ignored.

We have commented upon the well-known accumulation model of Goodwin on cyclical growth. Some arguments have been given why this model can benefit from an explicit treatment of bargaining elements. In the paper an alternative for Goodwin's assumption on a real Phillips-curve has been formulated by restating the game-theoretical Nash-solution for the puzzle of bargaining indeterminacy. The integration of the Nash-solution within a growth model enabled us to describe periodically the level as well as the distribution of income in case of compromise and cooperation on bargaining issues.

The proposed version of a Goodwin-plus-Nash-model yielded as the main result that the cycle disappears altogether: any compromise on distribution issues and wage formation always leads to a tendency towards a long run stable steady-state growth. This solution has been reached without use of extreme assumptions such as perfect forsight and rational expectations. The movement to a durable steady-state is virtually a periodical sequence of local Nash-solutions, requiring only the acceptance of the resulting Nash-dividends by the parties periodically. A compromise within the Goodwin-Nash model will be more in correspondence with specific class preferences, when the a priori wage and profit claims are more moderate and the accumulation quote of the capitalists is higher. Paradoxically, the more cooperative the parties are, the larger the forced disequilibrium during the adjustment process is, and therefore the more likely it is one or both of the parties will break up the compromise before steady-state has been reached.

Although our version of the Goodwin-plus-Nash model highlights steady-state is conditional upon a class-compromise on distribution issues and wage growth, it has unfortunately eliminated the cycle out of Goodwin's model. The cycle may be regained by a revaluation of significance of the employment rate within the exposed model. An extension with lags, myopic expectations and imperfect information may lead to different conclusions. This has to be pointed out by further research.

LITERATURE

Bishop R. (1964): a Zeuthen-Hicks Theory of Bargaining, Econometrica, XXXII, pp. 410-17.

Calmfors L. (1985): Trade Unionism, Wage Formation and Macroeconomic Stability, Scandinavian Journal of Economics - An Introduction, 87 (2) pp. 143-59.

Coddington A. (1968): Theories of the Bargaining Process, London.

Cross J. (1966): A Theory of the Bargaining Process, American Economic Review, 56, pp. 522-30.

Glombowski J. & Krüger M. (1984): Profit-Squeeze und Fall der Profitrate als Elemente eines integrierten überakkumulationsansatzes, Prokla 57, pp. 40-57.

Goodwin R. (1967): A Growth Cycle, from Essays in Economic Dynamics, 1984, pp. 165-70.

Harsanyi J. (1956): Approaches to the Bargaining Problem before and after the Theory of Games, Econometrica, XXIV, pp. 144-57.

Hicks J. (1932): The Theory of Wages, London.

Johanson L. (1979): The Bargaining Society and the Inefficiency of Bargaining, Kyklos 32, pp. 497-522.

Lancaster K. (1973): The Dynamic Inefficiency of Capitalism, Journal of Political Economy 81, pp. 1092-1109.

Lange P. (1984): Unions, Workers and Wage Regulation: The Rational Bases of Conflict; in Goldthorpe (ed.) Order and Conflict in Contemporary Capitalism, pp. 98-122, Oxford.

McDonald I. & Solow R. (1981): Wage Bargaining and Employment, American Economic Review 1971, pp. 896-908.

Menil De G. (1971): Bargaining: Monopoly Power versus Union Power, Cambridge Mass.

Nash J. (1950): The Bargaining Problem, Econometrica, XVIII, pp. 128-140.

Oswald A. (1985): The Economic Theory of Trade Unions: An Introductory Survey, Scandinavian Journal of Economics, 87(2), pp. 160-193.

Pen J. (1950): De Loonvorming in de moderne volkshuishouding, Leiden.

Pen J. (1952): A General Theory of Bargaining, American Economic Review, 42, pp. 24-42.

Pencavel J. (1985): Wages and Unemployment under Trade Unionism, Scandinavian Journal of Economics, 87(2), pp. 197-225.

Phillips A. (1958): The Relation between Unemployment and the Rate of Change of Money Wages in the United Kingdom, 1861-1957, Economica 25, pp. 283-299.

Przeworski A. & Wallerstein M. (1982): The Structure of Class Conflict in Democratic Society, American Political Science Review 76(2), pp. 215-39.

Roth A. (1979): Axiomatic Models of Bargaining, New York.

Selten R. & Güth W. (1982): Game Theoretical Analysis of Wage Bargaining in a Simple Business Cycle Model, Journal of Mathematical Economics 10, pp. 177-95.

Shubik M. (1952): A Business Cycle with Organized Labor Considered, Econometrica, XX, pp. 284-94.

Young O. (ed.) (1975): Bargaining: Formal Theories of Negotiations, Urbana.

Zeuthen F. (1930): Problems of Monopoly and Economic Warfare, London.

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